# The impact of the North Pacific warm blob on biogeochemical cycles

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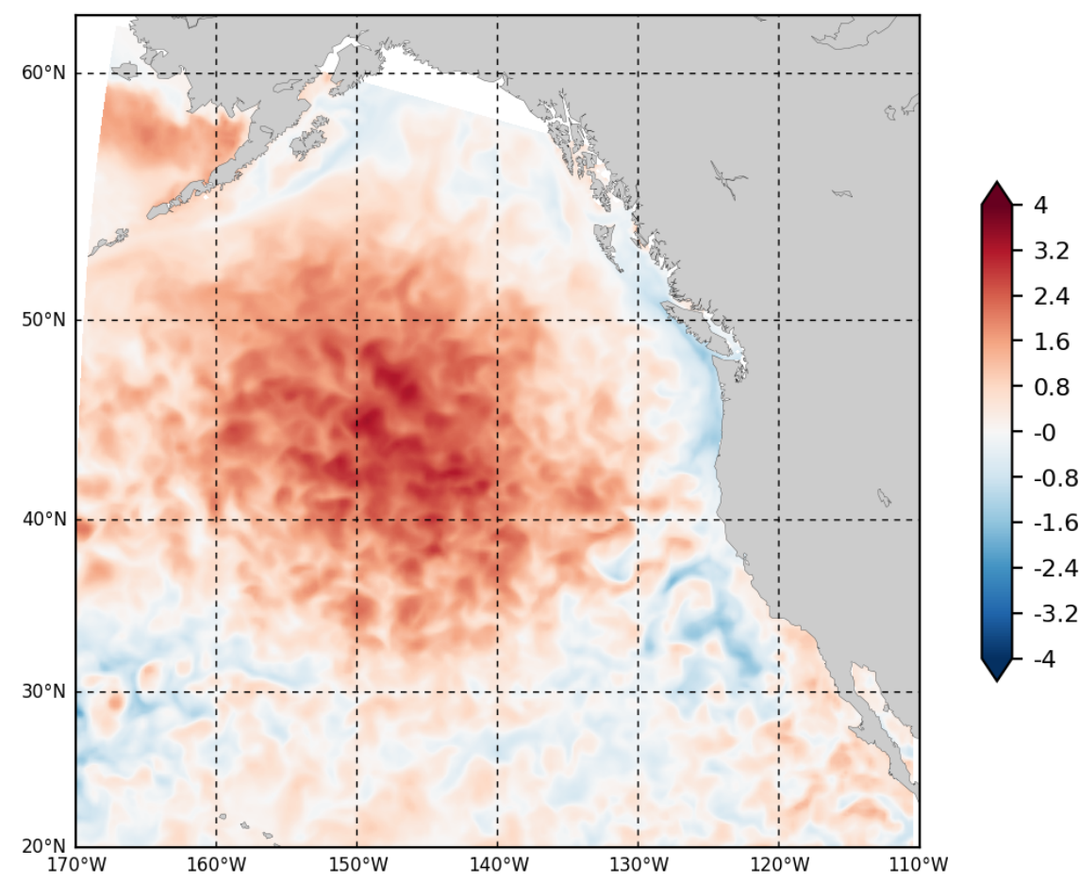
**Mercator Ocean International**

# The warm blob

- Largest marine heat wave ever recorded
- SST 1- 4°C higher than average from 2013-2015.
- Lower than normal rates of heat loss from the ocean
- Weak transport of colder water from the north due to anomalous winds

January 2014 SST anomaly




Mercator Ocean's operational model

Bond, et al. "Causes and impacts of the 2014 warm anomaly in the NE Pacific." *Geophysical Research Letters* 42.9 (2015): 3414-3420.

# Biological consequences: Coastal Ocean

**Well documented**

- Reduction in phytoplankton and primary production
- Increased mortality in copepods, krills, sea lions, whales
- Toxic algal bloom
- Invasion of warm-water fish species

Cavole, et al. "Biological impacts of the 2013–2015 warm-water anomaly in the Northeast Pacific: Winners, losers, and the future." *Oceanography* 29.2 (2016): 273-285.

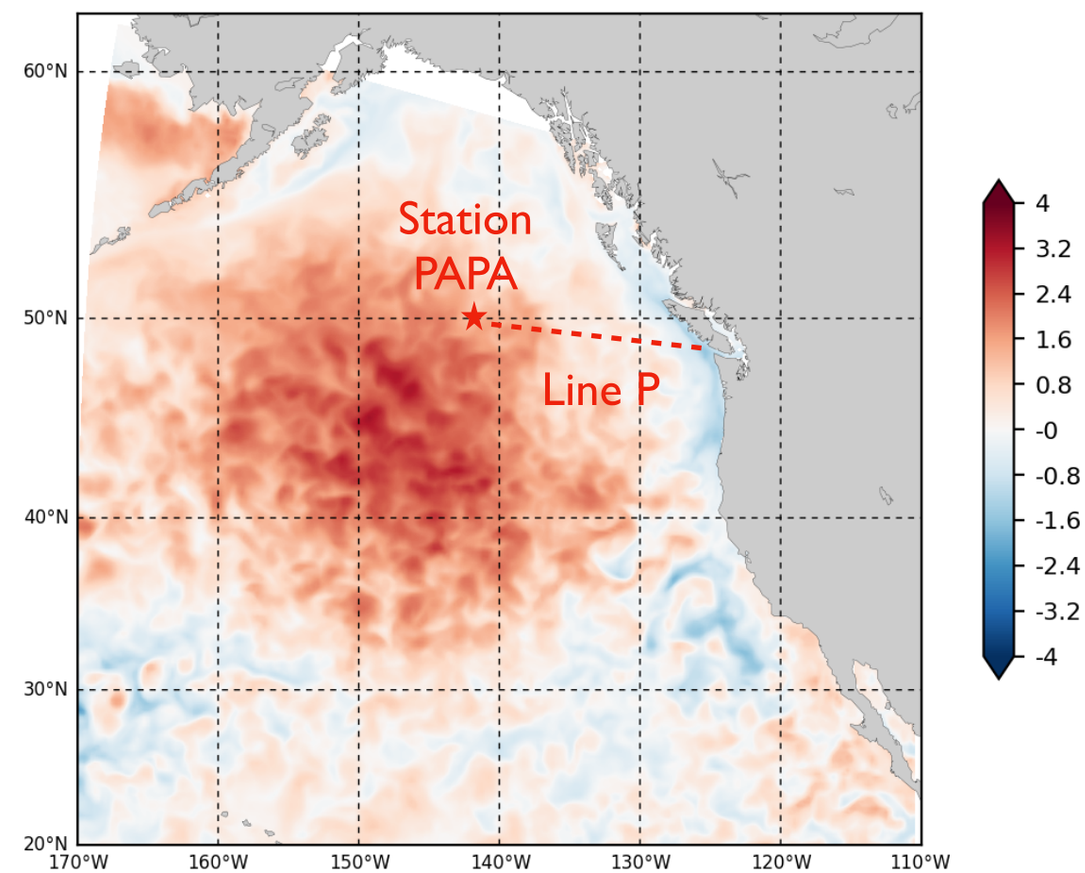
# Biological consequences: Open Ocean

**Less documented**

- Observations only rely on satellite measurements of chlorophyll, ocean station papa and line P program

- Decrease in nutrients, phytoplankton, and the flux of organic matter to the ocean interior, change in phytoplankton community composition

January 2014 SST anomaly

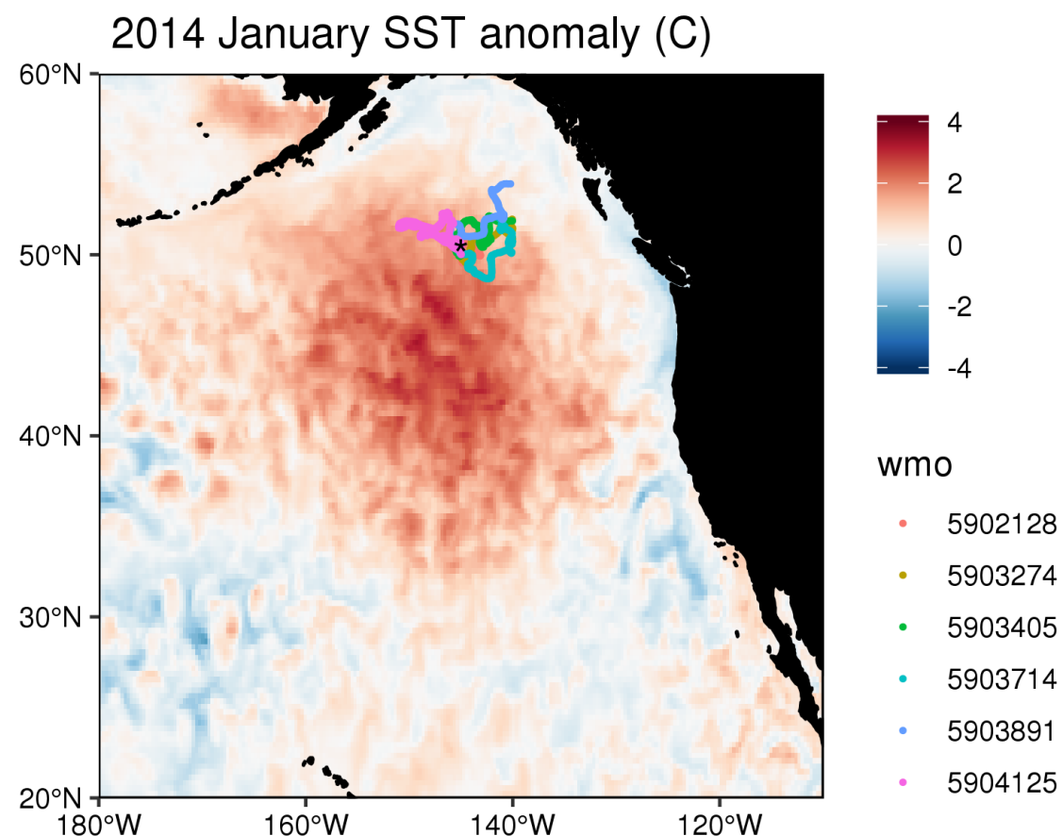


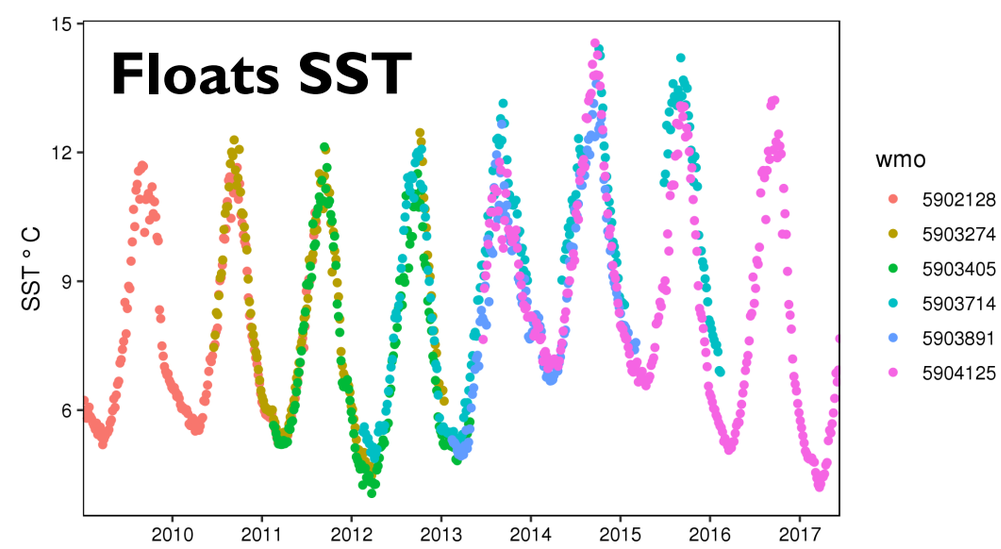

Mercator Ocean's operational model

Peña, et al. "Phytoplankton responses to the 2014–2016 warming anomaly in the northeast subarctic Pacific Ocean." *Limnology and Oceanography* 64.2 (2019): 515-525.

# Model validation

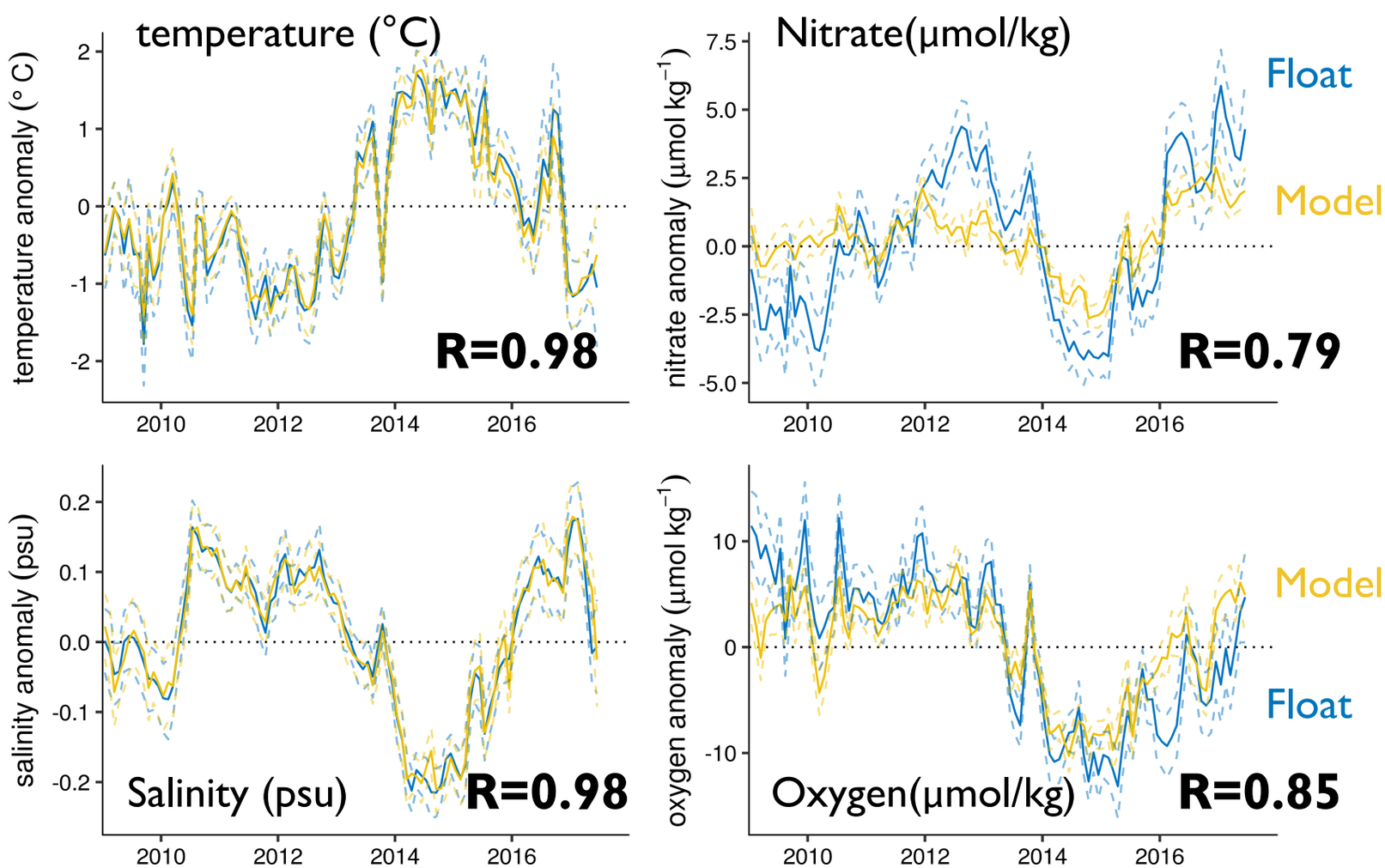
- 6 BGC-Argo floats deployed at PAPA, from 2009 to 2018.
- temperature, salinity, oxygen and nitrate data
- Phosphate, silicate, dissolved organic carbon and alkalinity predicted with a neural network




Bittig, , et al. "An Alternative to Static Climatologies: Robust Estimation of Open Ocean CO2 Variables and Nutrient Concentrations From T, S, and O2 Data Using Bayesian Neural Networks." *Frontiers in Marine Science* 5 (2018): Art-Nr.

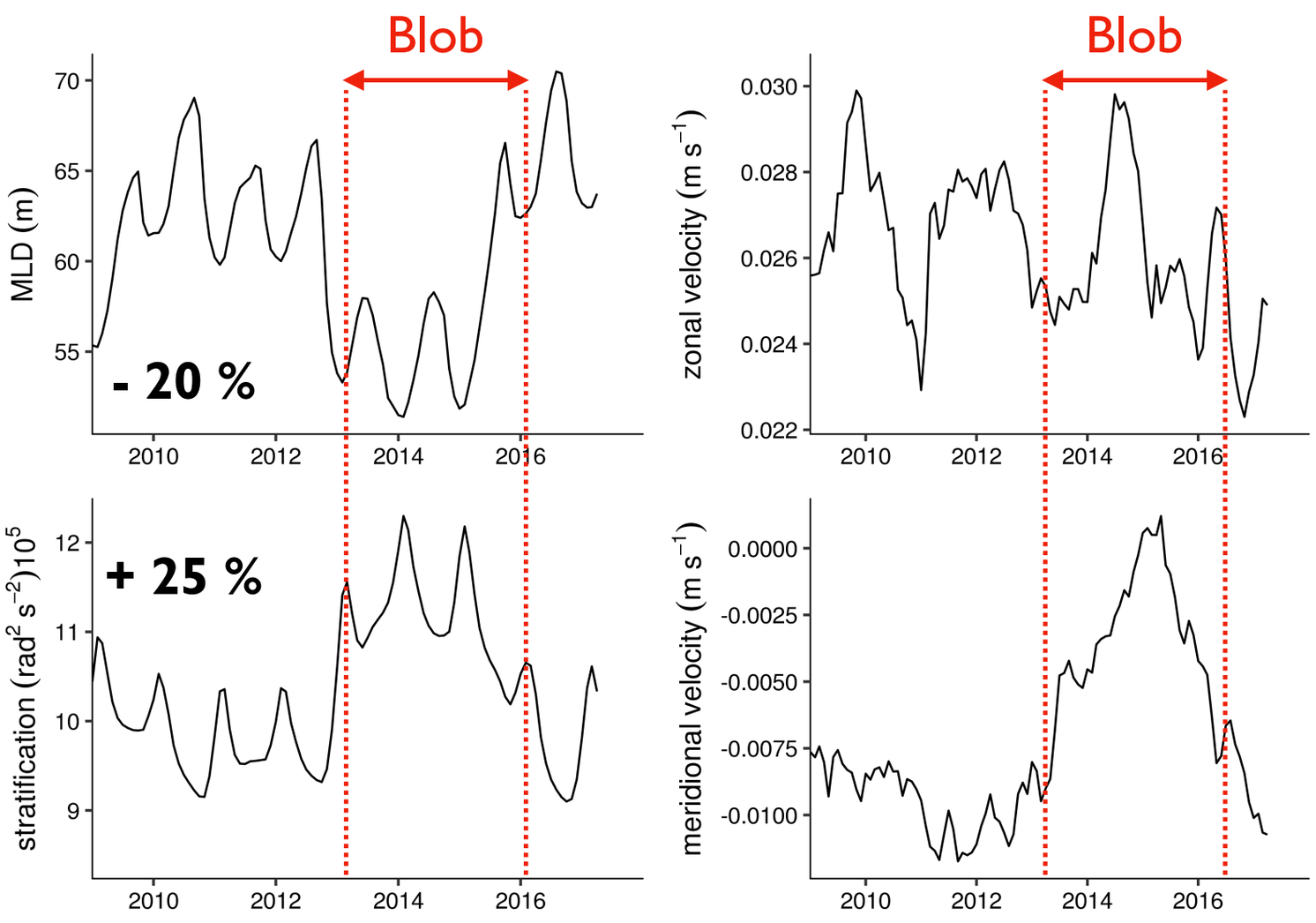
# Model validation

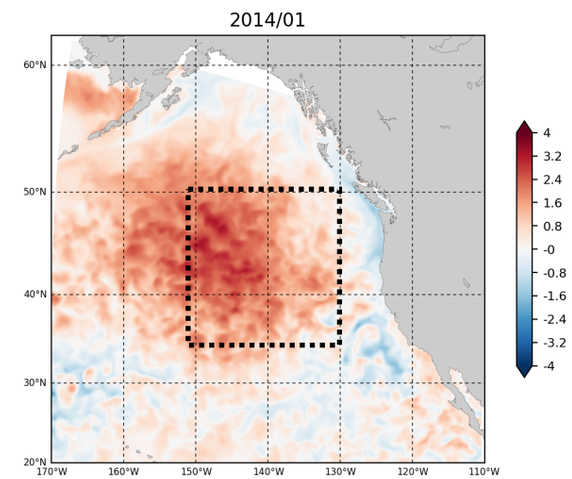



Surface temperature, salinity, nitrate and oxygen anomalies relative to 2008-2012

Silicate, R=0.74
Phosphate, R=0.76
DIC, R=0.84
Alkalinity, R=0.83

# Physical forcing

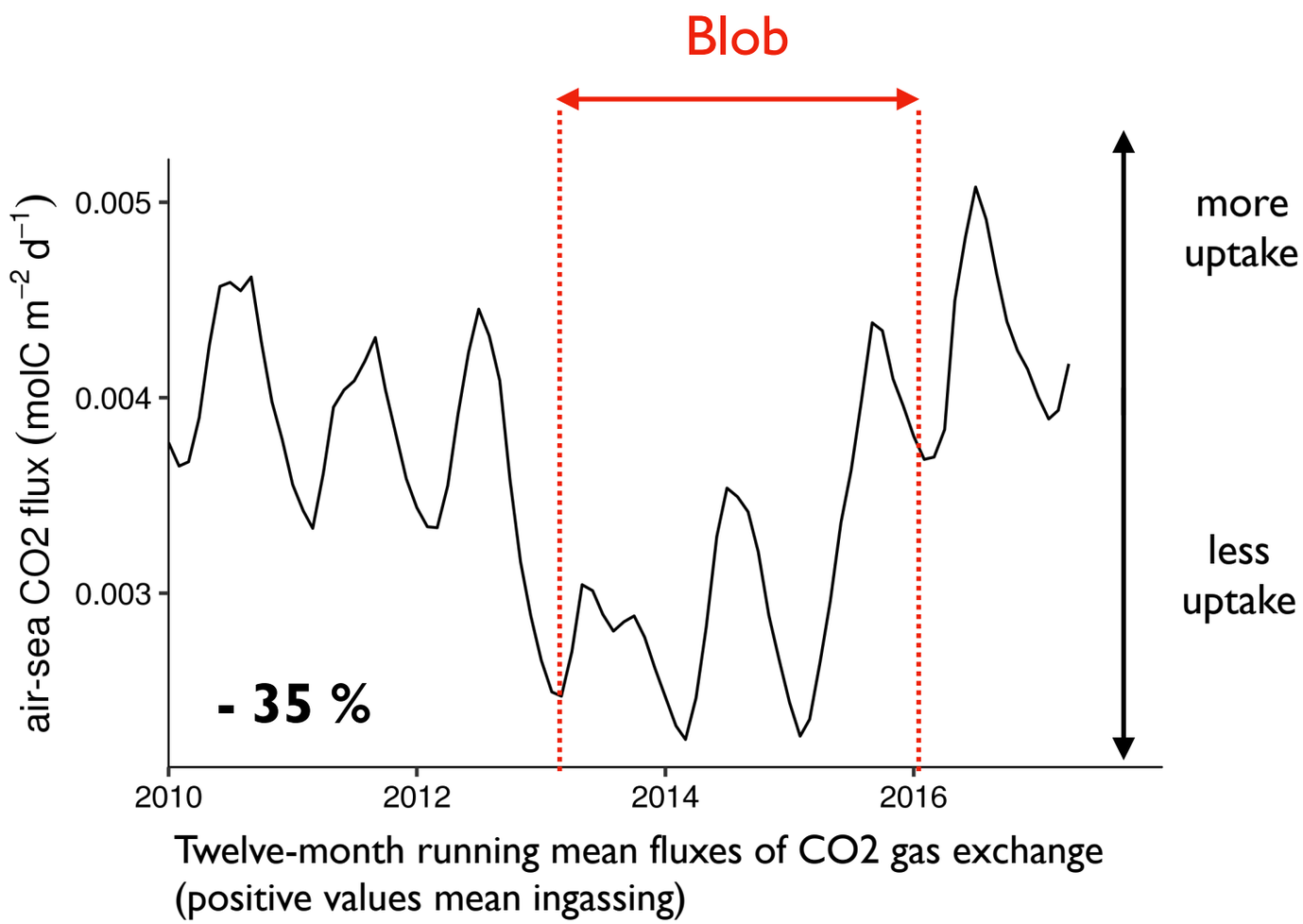



Twelve-month running mean of MLD, stratification, zonal and meridional velocities

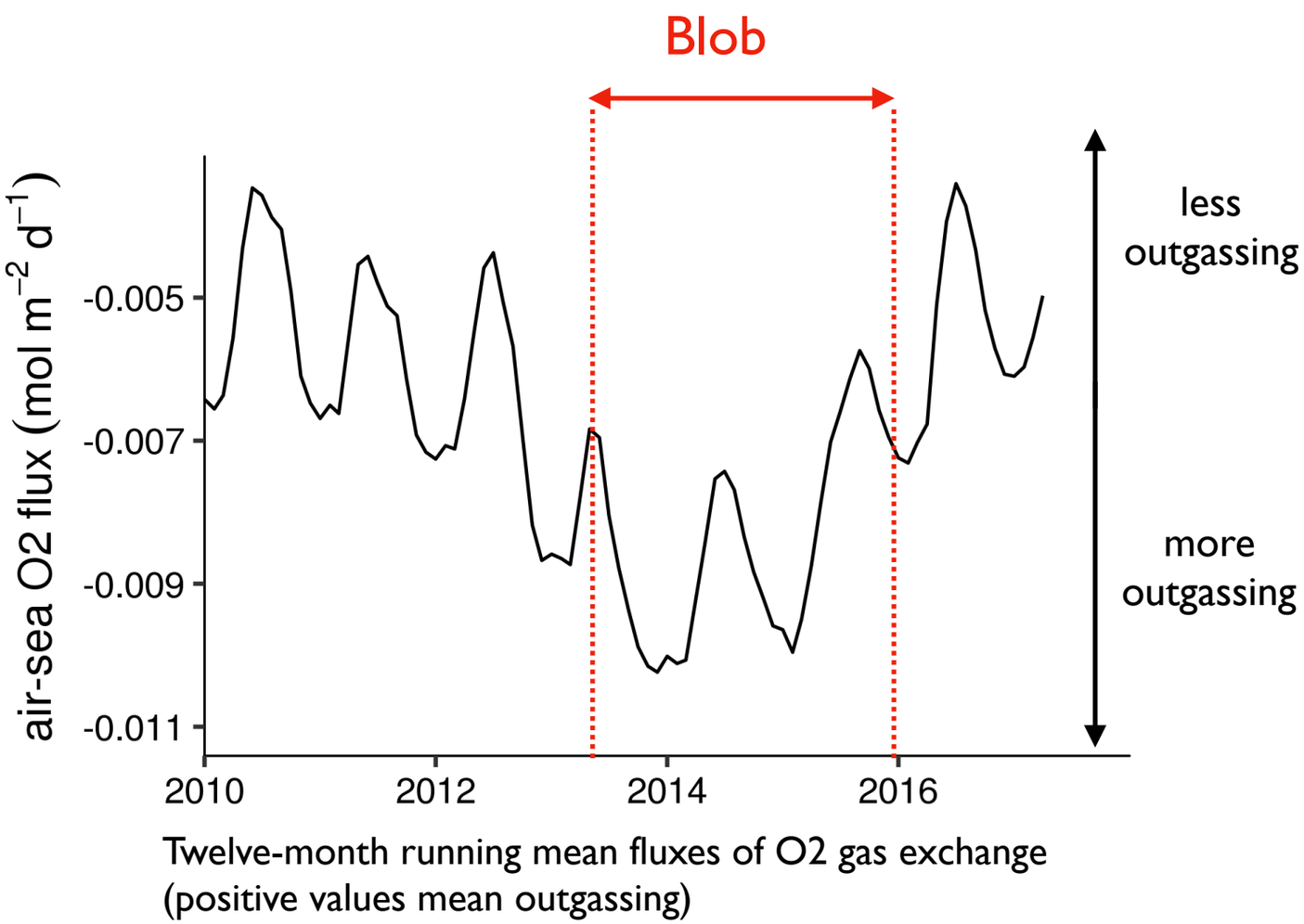
The blob triggered a decrease in mixed layer depth, an increase in stratification, and a reduction in the horizontal advection from the north

# Air-Sea CO2 flux

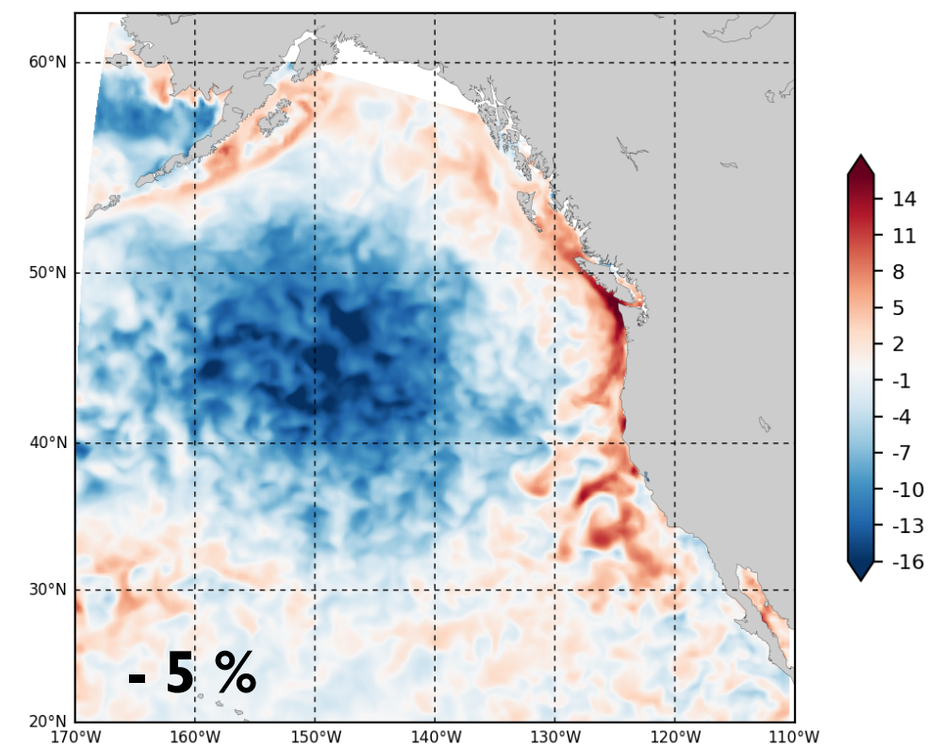



The uptake of CO2 from the atmosphere is reduced due to the increase in sea surface temperature

# Oxygen

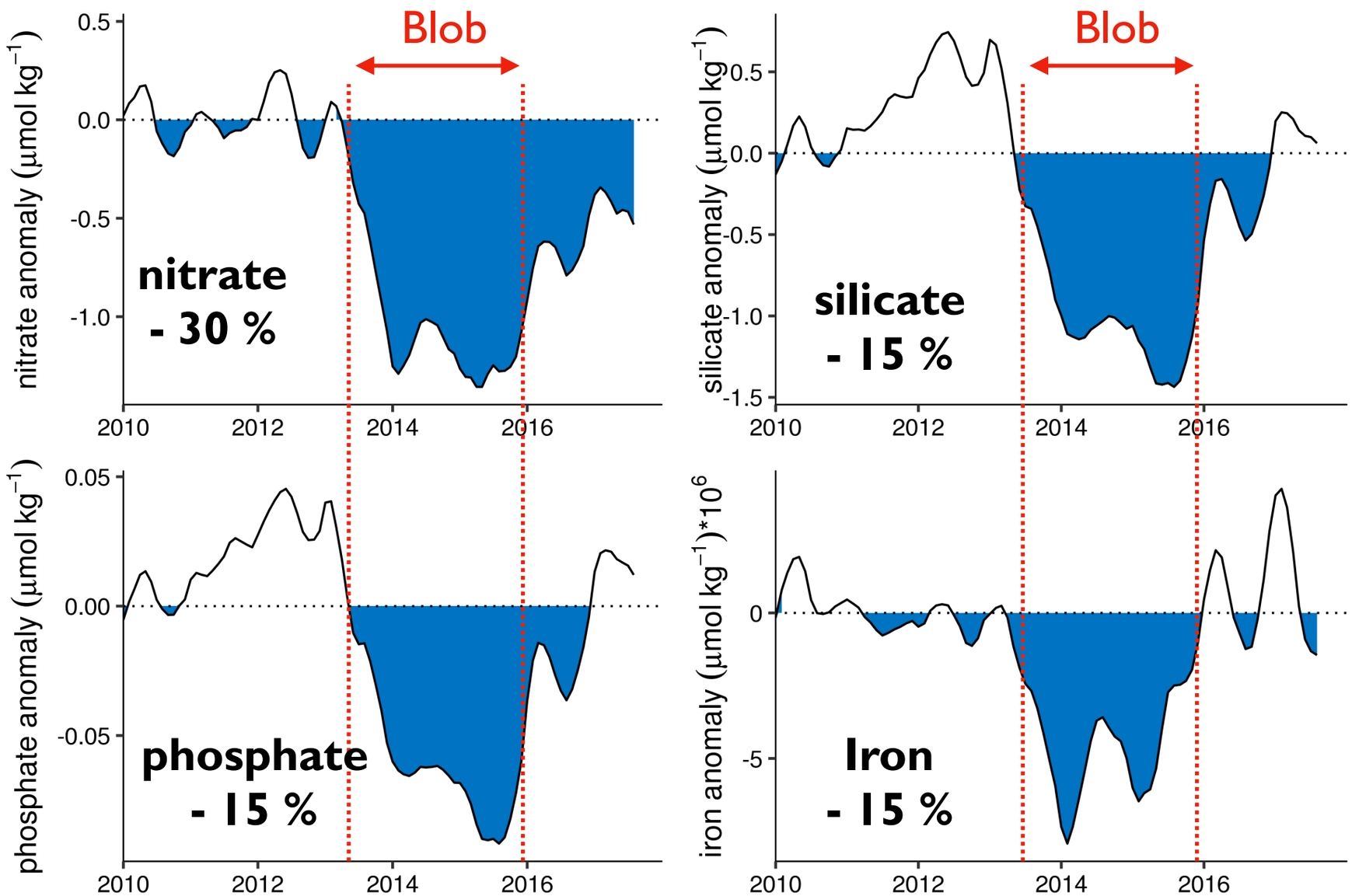



January 2014 surface oxygen anomaly




Surface oxygen concentrations are reduced due to the increase in sea surface temperature

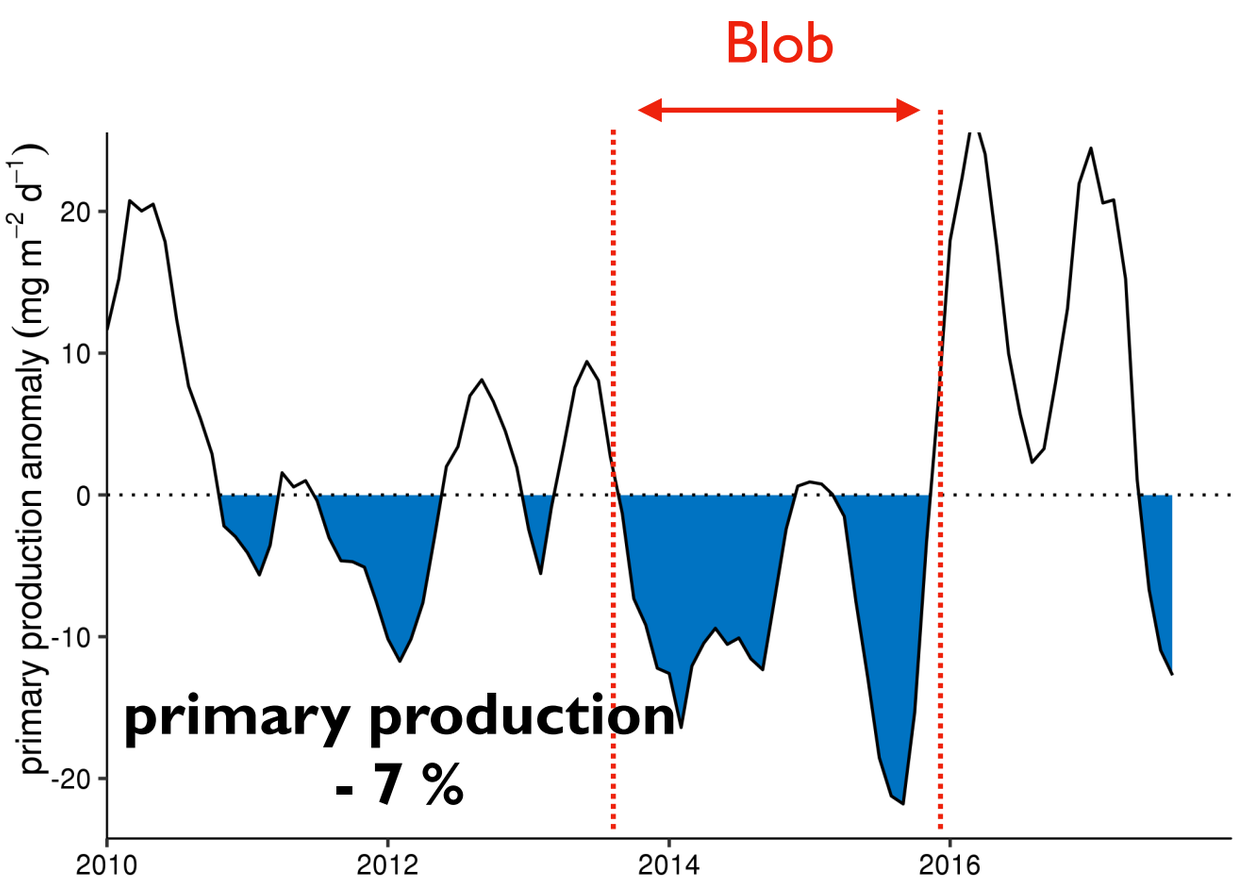
# Nutrients



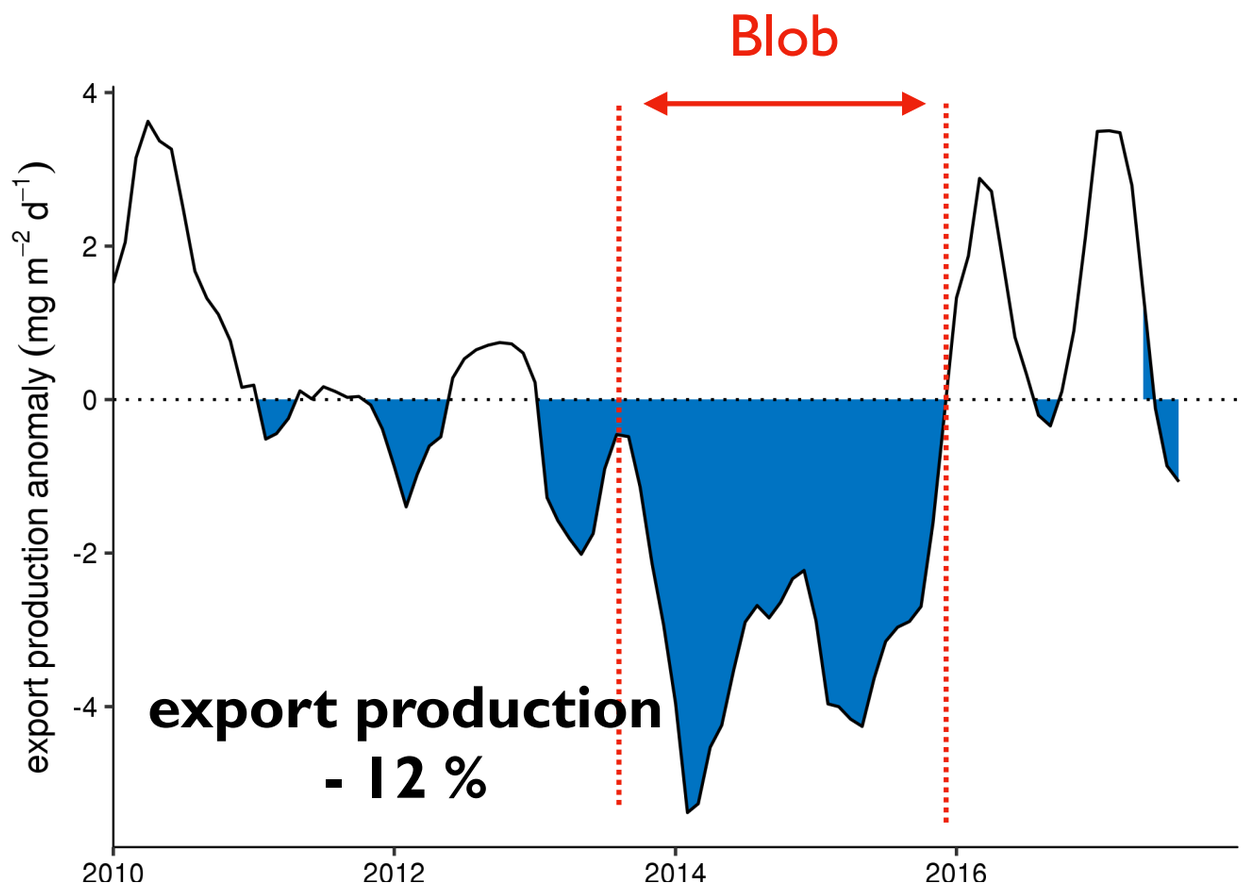

Surface nutrients anomalies relative to 2008-2012.

Surface nutrients are reduced due to the increase in vertical stratification, and the decrease in mixed layer depth and horizontal advection.

# Biological carbon pump



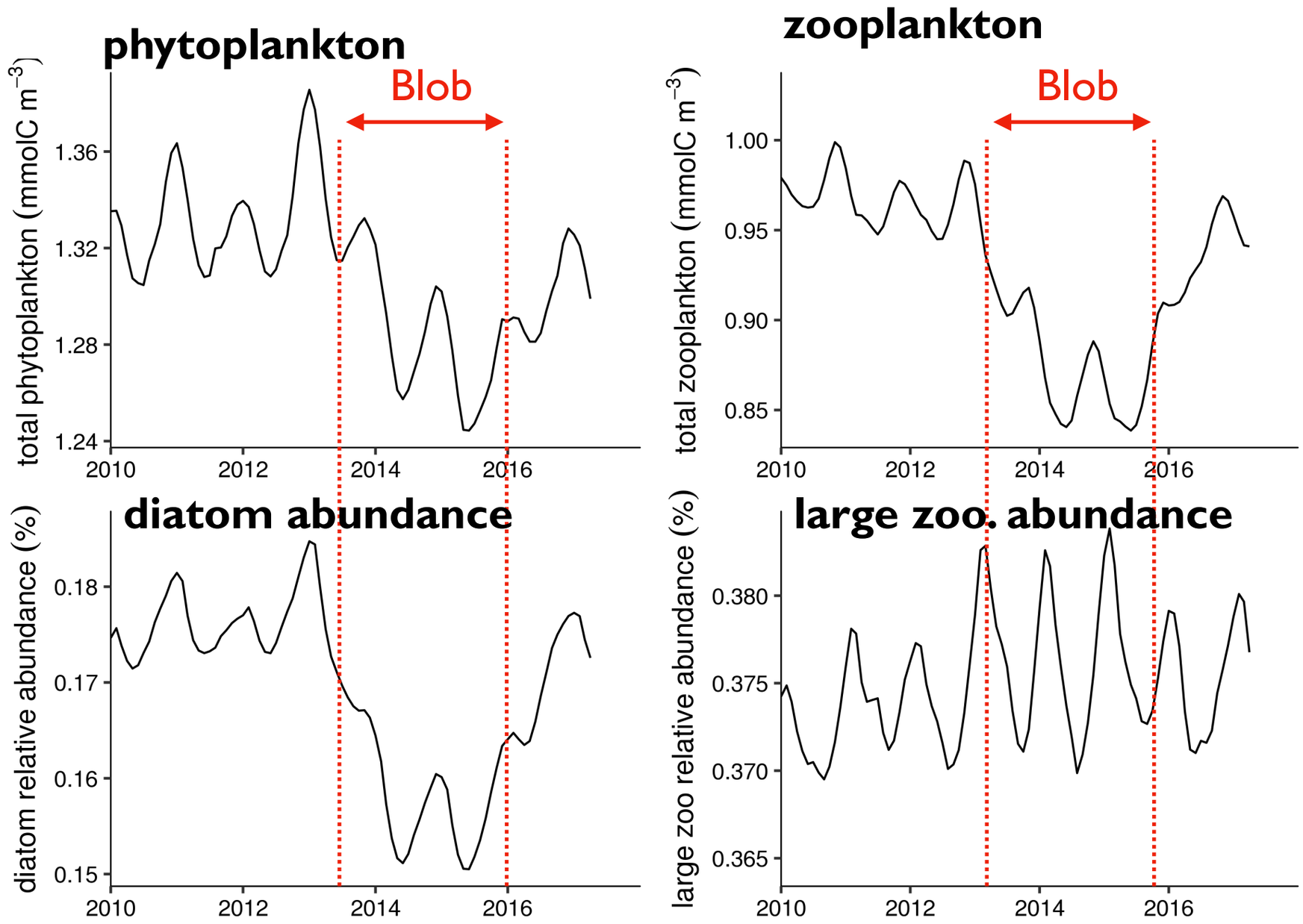

Depth-integrated primary production anomaly relative to 2008-2012




Export production at 100 m anomaly relative to 2008-2012

Primary and export production are reduced due to the decrease in the supply of nutrients.

# Phytoplankton and zooplankton




Twelve-month running mean phytoplankton and zooplankton biomass

There was a decrease in phytoplankton and zooplankton biomass, with a change in phytoplankton community composition (decrease in diatoms abundance)

# Conclusion

- We used an operational biogeochemical model to study the impact of the warm blob on biogeochemical cycles at the basin scale

- Comparison against BGC-Argo floats show that this kind of models are pertinent to detect anomalies in BGC cycles associated with marine heat waves

- We showed that there was a decrease in
    - **The uptake of CO2 from the atmosphere**
    - **Oxygen levels**
    - **Surface nutrients**
    - **Primary production**
    - **The flux of organic matter to the ocean interior**
    - **Phytoplankton and zooplankton biomass**

- Open up new possibilities for the study of marine heat waves and theirs impacts on the biogeochemical ocean and marine ecosystems: reanalysis, future climate projections, etc….